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(54) **PREDICTIVE APPROACH TO ENVIRONMENT PROVISIONING**

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(51) **Int. Cl.**

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G06F 9/44 (2006.01)
G06Q 10/06 (2012.01)

(52) **U.S. Cl.**

CPC ... ***G06Q 10/063114*** (2013.01); ***G06F 11/3664*** (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

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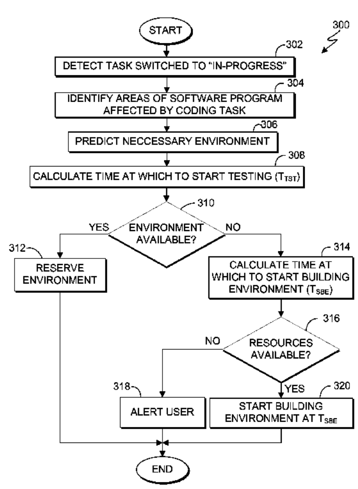
(57) **ABSTRACT**

Embodiments of the present invention provide methods, systems, and computer program products for building an environment. Embodiments of the present invention can be used to allocate resources and build an environment such that the environment is built when a user is prepared to test one or more portions of code in the environment. Embodiments of the present invention can be used to reduce the "lag time" developers experience between waiting for the code to be built and for resources to be provisioned, and can also provide a less costly alternative to maintaining and operating dedicated environments.

12 Claims, 5 Drawing Sheets



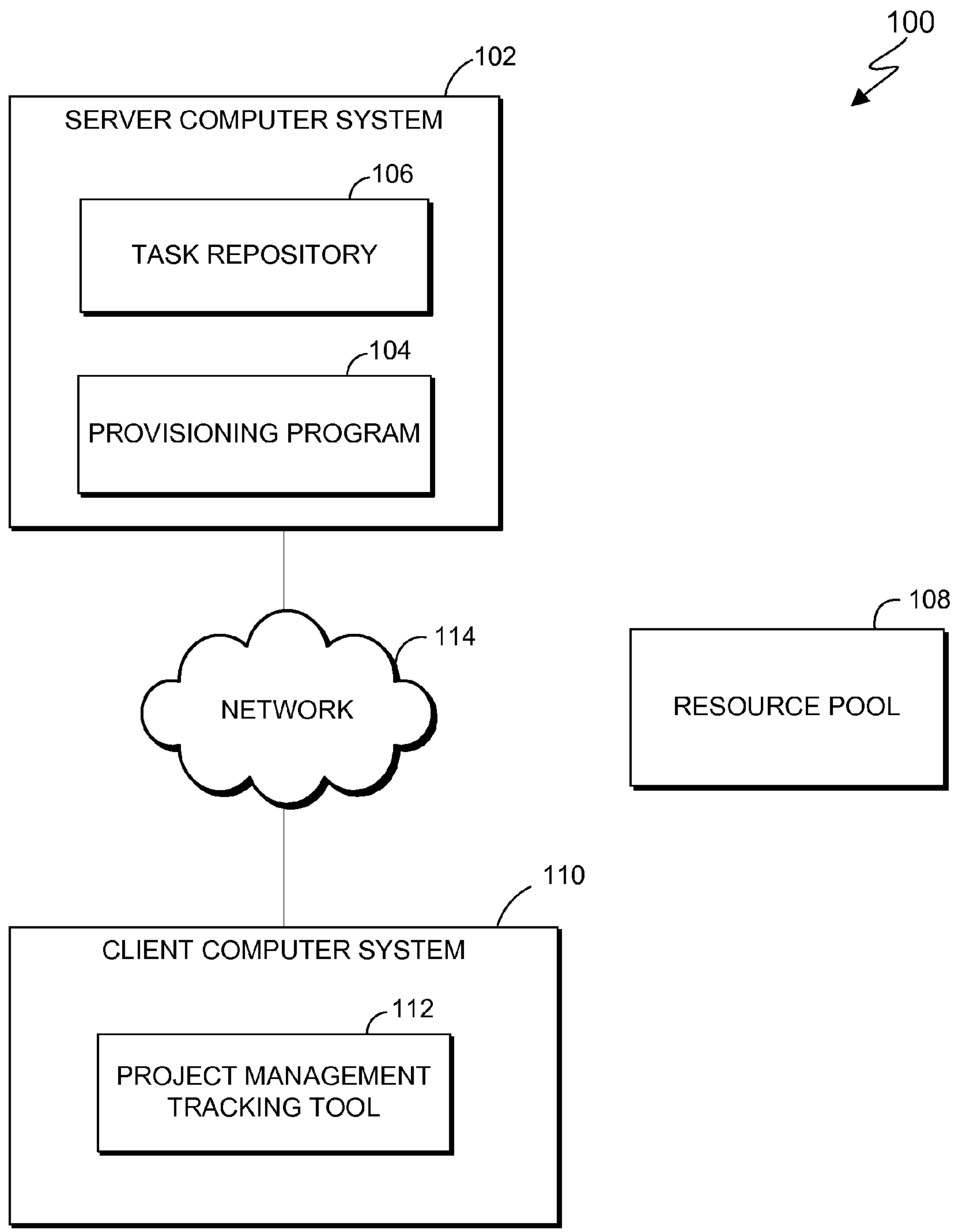

100
102
SERVER COMPUTER SYSTEM
106
TASK REPOSITORY
104
PROVISIONING PROGRAM
114
NETWORK
108
RESOURCE POOL
110
CLIENT COMPUTER SYSTEM
112
PROJECT MANAGEMENT TRACKING TOOL

FIG. 1

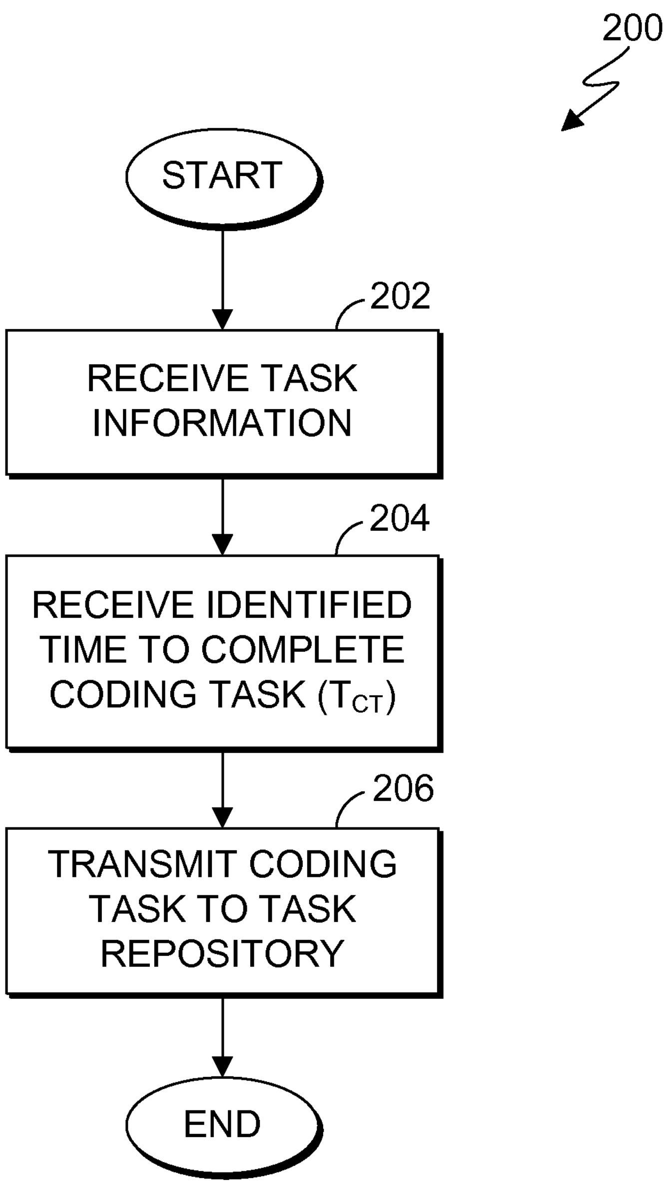

200
START
202
RECEIVE TASK INFORMATION
204
RECEIVE IDENTIFIED TIME TO COMPLETE CODING TASK (T_{CT})
206
TRANSMIT CODING TASK TO TASK REPOSITORY
END

FIG. 2

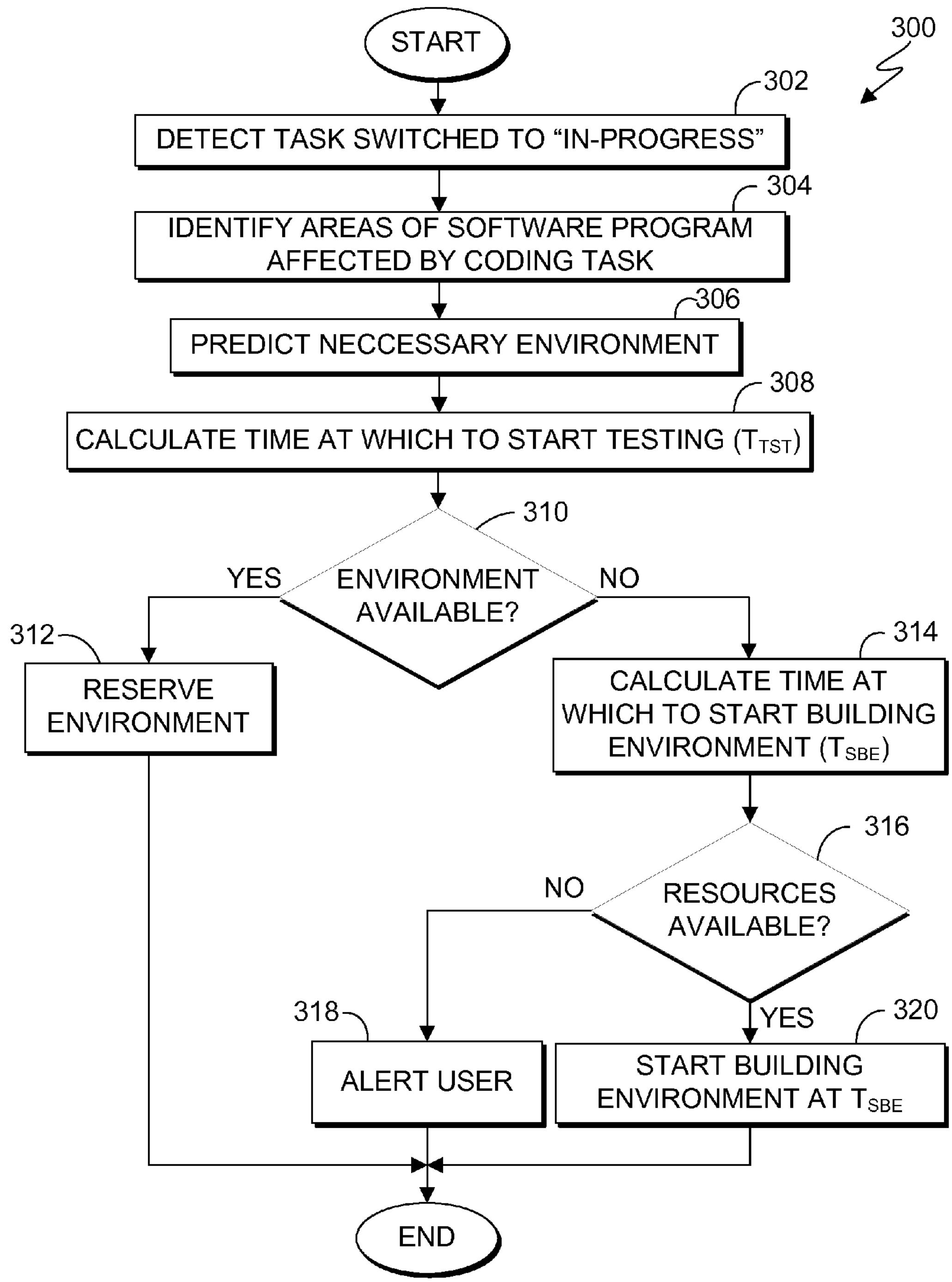

300
START
302
DETECT TASK SWITCHED TO "IN-PROGRESS"
304
IDENTIFY AREAS OF SOFTWARE PROGRAM AFFECTED BY CODING TASK
306
PREDICT NECCESSARY ENVIRONMENT
308
CALCULATE TIME AT WHICH TO START TESTING (T_{TST})
310
ENVIRONMENT AVAILABLE?
YES
NO
312
RESERVE ENVIRONMENT
314
CALCULATE TIME AT WHICH TO START BUILDING ENVIRONMENT (T_{SBE})
316
RESOURCES AVAILABLE?
NO
YES
318
ALERT USER
320
START BUILDING ENVIRONMENT AT T_{SBE}
END

FIG. 3

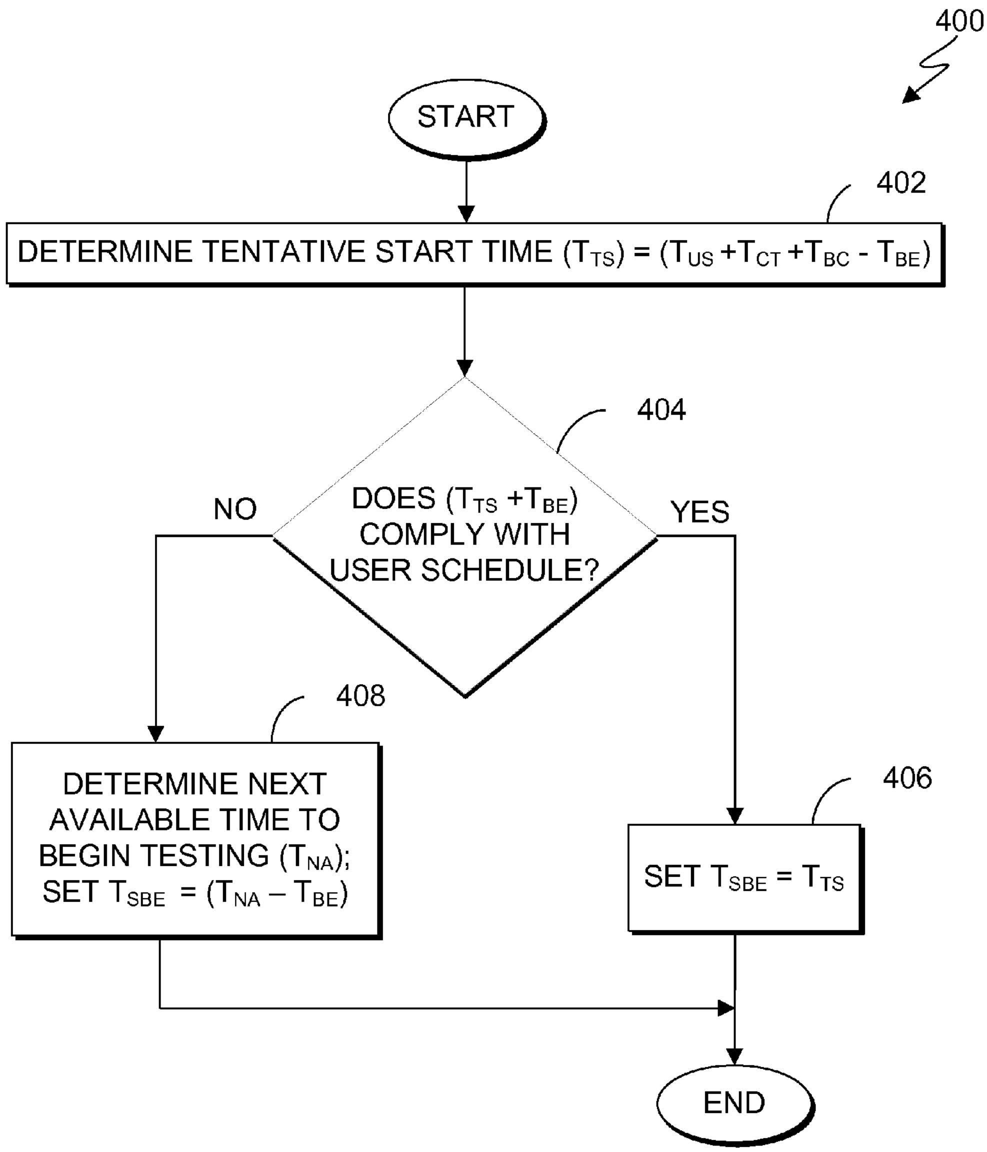

400
START
402
DETERMINE TENTATIVE START TIME (T_{TS}) = (T_{US} +T_{CT} +T_{BC} - T_{BE})
404
DOES (T_{TS} +T_{BE}) COMPLY WITH USER SCHEDULE?
NO
YES
408
DETERMINE NEXT AVAILABLE TIME TO BEGIN TESTING (T_{NA}); SET T_{SBE} = (T_{NA} – T_{BE})
406
SET T_{SBE} = T_{TS}
END

FIG. 4

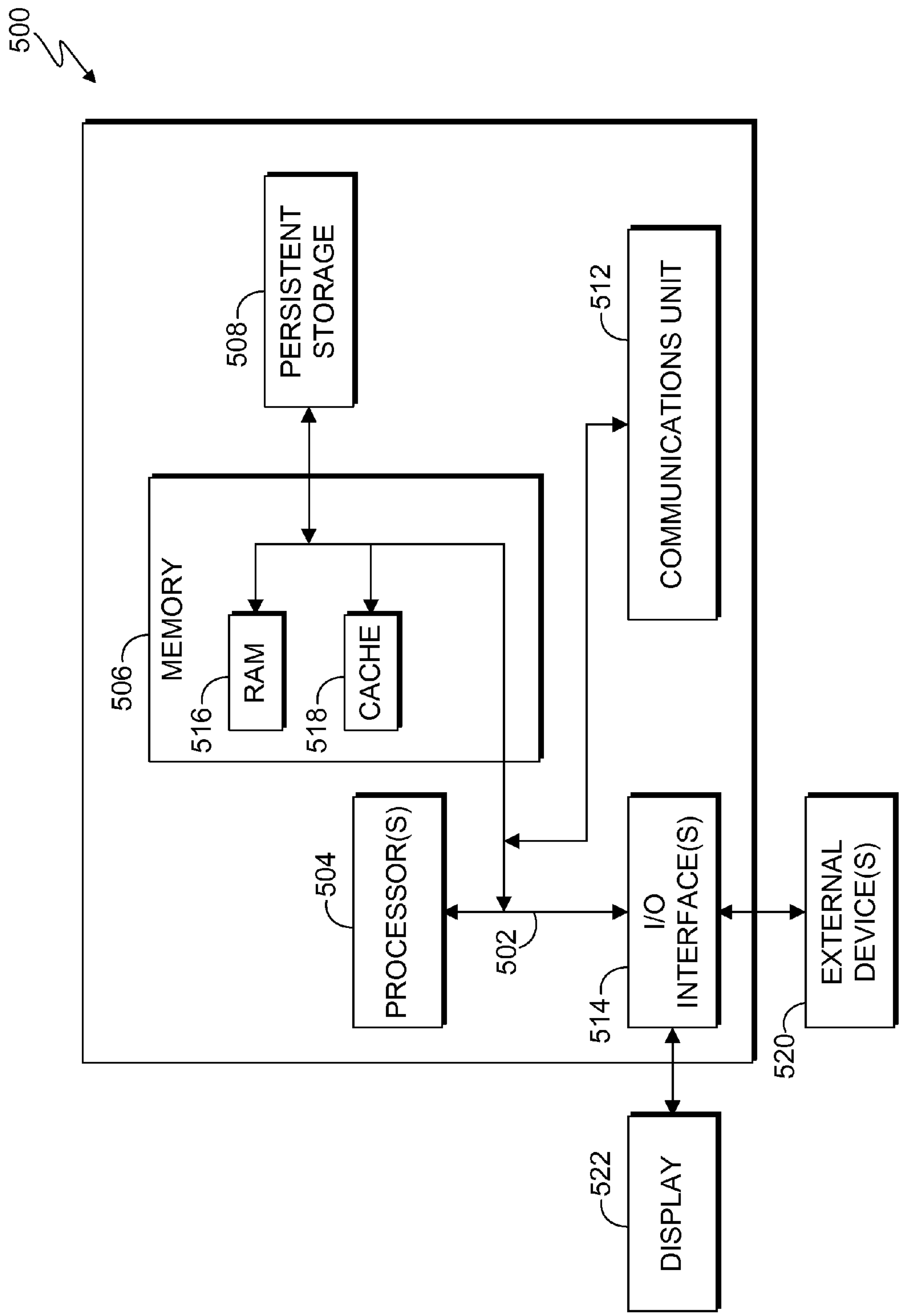

500
PERSISTENT STORAGE
508
MEMORY
506
RAM
516
CACHE
518
COMMUNICATIONS UNIT
512
PROCESSOR(S)
504
502
I/O INTERFACE(S)
514
EXTERNAL DEVICE(S)
520
DISPLAY
522

FIG. 5

PREDICTIVE APPROACH TO ENVIRONMENT PROVISIONING

FIELD OF THE INVENTION

The present invention relates generally to the field of test environments, and more particularly to provisioning resources for test environments.

BACKGROUND OF THE INVENTION

A computer software program needs to be evaluated to determine whether it achieves its particular or desired purpose. Generally, software testing is used to expose problems with the software to alert software engineers to debug the code in the software causing problems. Test environments are used to mimic the intended software and/or hardware environment in which the program will be deployed to ensure the program will perform its desired purpose for the end user.

Typically, after code is written for a software program, the software engineer must wait for the code to be "built". In the interim, the software engineer must build the software test environment to test the code and determine if it performs as desired. For example, a team of software engineers could use DevOps, a methodology of software development that helps an organization to rapidly produce software products and services, to provision resources for building test environments by selecting various pre-requisites and co-requisites that need to be installed to run the tests. Given the complexity of the environment, the provisioning could take hours to complete, and only then could the software engineers begin testing. Thus, software engineers can experience "lag time" between waiting for the code to be built and the creation of the test environment. In other instances, there could be dedicated environments already set up but are not being used.

SUMMARY

Embodiments of the present invention provide systems, methods, and program products for building an environment, such that the environment is built when the user is prepared to test the one or more portions of code in the environment. In one embodiment of the present invention, a method is provided comprising: identifying a coding task to be performed by a user involving one or more portions of code for a software program; identifying resources with which to build an environment for the coding task based, at least in part, on one or more areas of the software program associated with one or more portions of code; and calculating a time at which to start building the environment, such that the environment is built when the user is prepared to test the one or more portions of code in the environment.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a functional block diagram illustrating a computing environment, in accordance with an embodiment of the present invention;

FIG. **2** is a flowchart illustrating operational steps for creating a coding task, in accordance with an embodiment of the present invention;

FIG. **3** is a flowchart illustrating operational steps for building an environment, in accordance with an embodiment of the present invention;

FIG. **4** is a flowchart illustrating operational steps for predicting a time at which to start building an environment, in accordance with an embodiment of the present invention; and

FIG. **5** is a block diagram of internal and external components of the computer systems of FIG. **1**, in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION

Embodiments of the present invention recognize the need for ways to provide more efficient allocation of resources for building an environment. Embodiments of the present invention provide systems, methods, and computer program products for predicting a necessary environment and ensuring the environment is available to be used for testing when a developer's build is completed and ready to be tested. Accordingly, embodiments of the present invention can help reduce the "lag time" developers experience between waiting for the code to be built and for resources to be provisioned to build an environment to test one or more portions of code, and can provide a less costly alternative to maintaining and operating dedicated environments.

FIG. **1** is a functional block diagram of computing environment **100**, in accordance with an embodiment of the present invention. Computing environment **100** includes server computer system **102** and client computer system **110**. Server computer system **102** and client computer system **110** can be desktop computers, laptop computers, specialized computer servers, or any other computer systems known in the art. In certain embodiments, server computer system **102** and client computer system **110** represent computer systems utilizing clustered computers and components to act as a single pool of seamless resources when accessed through network **114**. In general, server computer system **102** and client computer system **110** are representative of any electronic devices, or combination of electronic devices, capable of executing machine-readable program instructions, as described in greater detail with regard to FIG. **5**.

Server computer system **102** includes provisioning program **104** and task repository **106**. Provisioning program **104** monitors task repository **106**, and allocates resources from resource pool **108** via network **114** to build environments for various coding tasks. Provisioning program **104** further calculates a time at which to start building environments for coding tasks, such that the environments are built when the user is prepared to test the one or more portions of code in the environments. The term "environment", as used herein, refers generally to an environment used to test code written for, and/or otherwise affected by, a coding task. An environment may be, for example, a test environment built specifically to test one or more portions of code, a staging environment (e.g., pre-production environment), and/or an actual production environment (i.e., where code is ultimately deployed and made available for use by end users).

Task repository **106** stores tasks received from project management tracking tool **112** via network **114**. Task repository **106** can be implemented using any non-volatile storage media known in the art. For example, task repository **106** can be implemented with a tape library, optical library, one or more independent hard disk drives, or multiple hard disk drives in a redundant array of independent disks (RAID). Similarly, task repository **106** can be implemented with any suitable storage architecture known in the art, such as a relational database, an object-oriented database, and/or one or more tables.

Resource pool **108** comprises hardware and software resources to be allocated by provisioning program **104** when building an environment for a coding task. For example, resource pool **108** may comprise a plurality of computer systems with various software installed thereon, coupled to a plurality of databases and/or other devices. In general, resource pool **108** represents any hardware, software, and combinations thereof that may be provisioned for building an environment with which to test programming code written for, and/or otherwise affected by, one or more coding tasks. For example, resource pool **108** may include a plurality of web servers, client computer systems, and web browsers that can be provisioned to build environments to test program code of a web application.

Network **114** can be, for example, a local area network (LAN), a wide area network (WAN) such as the Internet, or a combination of the two, and include wired, wireless, or fiber optic connections. In general, network **114** can be any combination of connections and protocols that will support communications between server computer system **102**, resource pool **108**, and client computer system **110**, in accordance with a desired embodiment of the invention.

Client computer system **110** includes project management tracking tool **112**. Project management tracking tool **112** enables a user to create and define coding tasks. A coding task involves creation and/or modification of one or more portions of code of one or more software programs. Project management tracking tool **112** communicates with server computer system **102** via network **114** (e.g., using TCP/IP) to store task information in task repository **106**. Task information describes one or more portions of a software program that needs to be created and/or modified. For example, project management tracking tool **112** can be implemented with any program that provides an integrated environment for creating and storing one or more coding tasks, monitoring its progress, and coordinating between one or more developer teams.

FIG. **2** is a flowchart **200** illustrating operational steps for creating a coding task, in accordance with an embodiment of the present invention.

In step **202**, project management tracking tool **112** receives task information for the coding task being created. In this embodiment, task information is received from a user of client computer system **110**. Task information comprises a title, a brief description of the coding task, what type of code needs to be written, areas of the software program affected by a coding task, and a default status of "not started". For example, the title of the coding task could be "Modification of Web Application Module". A brief description could specify that the module that allows access to a database is malfunctioning, while the area of the software program affected could indicate that the entire web application, the module that allows access to a database, and the servers that host the web application are areas affected by the coding task. The task information can further specify that code for the module needs to be rewritten or otherwise modified, and the time estimated to complete the coding task is 4 hours.

In step **204**, project management tracking tool **112** receives the identified length of time to complete coding task (T_{CT}) for the coding task being created. T_{CT} represents the length of time it takes to complete a coding task (i.e., 4 hours to complete writing code for a module to access a database). In this embodiment, T_{CT} is received from a user of client computer system **110**. For example, a user creating the coding task may specify an estimated time on the order of 4 hours, 8 hours, or 16 hours.

In step **206**, project management tracking tool **112** creates and transmits the coding task to server computer system **102** via network **114** for storage in task repository **106**. In this embodiment, after performing the operational steps of FIG. **2**, a user responsible for completing the coding task can subsequently access the created coding task in task repository **106** to begin work on the coding task.

FIG. **3** is a flowchart **300** illustrating operational steps for building an environment for a coding task stored in task repository **106**, in accordance with an embodiment of the present invention. For illustrative purposes, the following discussion is made with respect to a single example coding task and building of a test environment for the coding task, it being understood that the operational steps of FIG. **3** may be performed for a plurality of different coding tasks, and the environment built can be any desired type of environment.

In step **302**, provisioning program **104** detects that a coding task stored in task repository **106** has changed to an "in-progress" status. In this embodiment, each coding task stored in task repository **106** is associated with a status that indicates it state. Statuses can include, "not started", "in-progress", and "completed". In this embodiment, provisioning program **104** queries task repository **106** pursuant to a schedule to determine whether any coding task statuses have changed from "not started" to "in-progress", which indicates that a user has begun work on a coding task. In alternative embodiments, provisioning program **104** can receive indications of status changes directly from another program, such as from project management tracking tool **112**.

In step **304**, provisioning program **104** identifies areas of the software program affected by the coding task. In this embodiment, provisioning program **104** identifies areas of the software program affected by the coding task by accessing task repository **106** and analyzing the task information for the coding task. As previously discussed, a user who created the coding task may have specified one or more affected areas of the software program which provisioning program **104** can identify in step **302**. In addition, provisioning program **104** can analyze task information, such as the title and brief description of the coding task, to identify affected areas of the software program. For example, by analyzing a title of "Modification Web application Module" and a description specifying that the web application module must be modified such that it properly accesses a database, provisioning program **104** can identify areas of the software program affected by the coding task as including the web application module and other portions of code involved in accessing the subject database.

In step **306**, provisioning program **104** predicts a necessary environment for the coding task. Predicting a necessary environment for a coding task involves identifying resources in a resource pool needed to create an environment for testing program code written for, and/or otherwise affected by the coding task. In this embodiment, provisioning program **104** accesses task repository **106** for the task description transmitted to task repository **106** to calculate the necessary environment based on the identified areas of the software program affected by the coding task. For example, where the coding task involves writing code for a web module that accesses a database, provisioning program **104** identifies that a plurality of servers are coupled to a database, and configures those resources with the necessary software, settings, and operational parameters that are needed to test the functionality of the web module. In alternative embodiments, provisioning program **104** could also predict the necessary environment based on any specific resources indicated by a user who created the coding task, or based on environments that have been historically needed for similar coding tasks, or any combination thereof.

In step **308**, provisioning program **104** calculates a time at which to start testing (T_{TST}). T_{TST} represents the predicted time when one or more portions of code will be ready for testing. In this embodiment, provisioning program **104** calculates T_{TST} by adding an identified user start time (T_{US}) at which a user responsible for completing the coding task begins work on the coding task, an identified length of time it takes a user to complete a coding task (T_{CT}), and an identified length of time it takes for the code to be compiled into an executable program (T_{BC}). For example, provisioning program **104** might identify the values it needs as, T_{US} to be 9:00 am, T_{CT} to be 2 hours, and T_{BC} to be 3 hours. Provisioning program **104** would then calculate T_{TST} by adding the values for T_{CT} and T_{BC} (2 hours plus 3 hours), and adjusting T_{US} (9:00 am) by 5 hours ($T_{CT}+T_{BC}$) to give a T_{TST} of 2:00 pm.

In this embodiment, provisioning program **104** identifies T_{US} as the time a user responsible for completing the coding task accesses the created coding task in task repository **106** to begin work on the coding task, which causes the coding task status to switch from "not started" to "in-progress". In alternative embodiments, provisioning program **104** can receive an indication from project management tracking tool **112** when the user begins work on the coding task and use that time as T_{US}. In other embodiments, provisioning program **104** could confirm T_{US} with project management tracking tool **112** before proceeding. For example, provisioning program **104** could query project management tracking tool **112**, which in turn prompts the user of project management tracking tool **112** to input T_{US}.

In this embodiment, provisioning program **104** identifies T_{CT} as the length of time to complete the coding task by accessing stored task information in task repository **106** which contains a user identified length of time to complete coding task.

In this embodiment, provisioning program **104** uses historical data to identify T_{BC}. Historical data in this example could be the stored data from previous builds (i.e., how long it took to build a type of code). For example, provisioning program **104** uses historical data, and it indicates that it took 2 hours to build that code; then provisioning program **104** sets that value as T_{BC}.

In step **310**, provisioning program **104** determines whether an environment for the coding task will be available for use (i.e., potentially obviating the need to build the predicted environment). An environment can be regarded as available for use if it is currently in use but will be available at T_{TST} or within a specified amount of time from T_{TST}. An environment can also be regarded as available if it will be in use at T_{TST} but can be simultaneously used to test the completed coding task. In this embodiment, provisioning program **104** accesses resource pool **108** to determine whether an environment will be available for use. For example, provisioning program **104** could access resource pool **108** and identify that a particular environment comprising the needed resources for the coding task is currently in use but will be available within five minutes after T_{TST}.

If, in step **310**, provisioning program **104** determines an environment will be available for use, then, in step **312**, provisioning program **104** reserves the environment for testing the one or more portions of program code for the completed coding task. In this embodiment, reserving the environment prevents allocated resources of the environment from being reallocated for other purposes, and also prevents the environment from being reserved by other applications. For example, provisioning program **104** may determine that a particular environment for a first coding task is already built and will be available for use at T_{TST} for a second coding task. Provisioning program **104** would then prevent resources of that environment from being reallocated for other purposes, and also prevent that environment from being reserved by other applications.

If, in step **310**, provisioning program **104** determines an environment is not available for use, then, in step **314**, provisioning program **104** predicts a time at which to start building the environment for the coding task (T_{SBE}). In this embodiment, provisioning program **104** predicts T_{SBE} by subtracting the identified length of time to build an environment (T_{BE}) which represents the identified length of time needed to identify and allocate resources in resource pool **108** and configure those resources to test one or more portions of program code written for, or otherwise affected by, the coding task from T_{TST}. For example, provisioning program **104** might identify T_{ST} as 2:00 pm and T_{BE} as one hour. Provisioning program **104** would then calculate T_{SBE} by adjusting T_{ST} (2:00 pm) by T_{BE} (one hour) to yield a T_{SBE} of 1:00 pm.

In this embodiment, provisioning program **104** uses historical data to identify T_{BE}. Historical data includes saved times for how long provisioning program **104** took to build environments for one or more previous similar coding tasks. For example, when identifying T_{BE} for a coding task that called for a modification to a module for a web application, provisioning program **104** can check historical data to determine how long it previously took to provision resources to build similar environments and use that values as T_{BE}. Other embodiments can use other techniques, such as using preset values based on resources (e.g., preset of X minutes for each server that must be provisioned, and Y minutes for each database), and adding those values to arrive at T_{BE}. For example, provisioning program **104** might identify a server (preset value of 40 minutes to build) and a database (preset value of 20 minutes to build) are needed for the environment. Provisioning program **104** could then identify T_{BE} by adding those values for a server and a database (40 minutes+20 minutes) to give T_{BE} a value of 60 minutes.

In step **316**, provisioning program **104** determines whether needed resources are available to build the environment for the coding task. In this embodiment, provisioning program **104** accesses resource pool **108** and checks whether the resources identified in step **306** will be available by T_{SBE}. For example, provisioning program **104** might predict that T_{SBE} for a coding task is 1:00 pm. Provisioning program **104** would then access resource pool **108** and determine whether the needed resources will be available at 1:00 pm (e.g., needed resources will not be allocated for another environment at 1:00 pm, and/or needed resources will be allocated but can be shared).

If, in step **316**, provisioning program **104** determines that needed resources are not available to build the environment for the coding task, then, in step **318**, provisioning program **104** alerts the user. In this embodiment, the alert indicates that resources will not be available. Accordingly, a user could then decide to work on another task. In other embodiments, provisioning program **104** could identify tasks for which environments or resources would be available for testing if the task was started now. For example, provisioning program **104** could access task repository **106**, identify the "not started" tasks, and perform the previously discussed steps as if the "not started" tasks were just started.

If, in step **316**, provisioning program **104** determines that needed resources are available to build the environment for the coding task, then, in step **320**, provisioning program **104** starts building the environment for the coding task at T_{SBE}. In this embodiment, provisioning program **104** builds the environment by provisioning and configuring resources for the coding task from resource pool **108** at T_{SBE}.

Accordingly, in this embodiment, provisioning program **104** starts building an environment for the coding task so that the environment is built and ready for testing by the time the coding task is completed. In some instances, provisioning program **104** may identify an existing environment that can be used for the coding task, obviating the need to build another environment. Thus, this embodiment can be used to provision resources from a resource pool in a more efficient way and reduce "lag time" developers experience while waiting for an environment to be built.

FIG. **4** is a flowchart **400** illustrating operational steps for predicting a time at which to start building an environment, in accordance with an embodiment of the present invention. For example, operational steps of flowchart **400** can be performed at step **314** of flowchart **300**. For illustrative purposes, the following discussion is made with respect to a single example coding task and building of a test environment for the coding task, it being understood that the operation steps of FIG. **4** may be performed for a plurality of different coding tasks, and the environment built can be any desired type of environment.

In step **402**, provisioning program **104** calculates a tentative start time (T_{TS}), which is an initial calculation of a time to start building the environment. In this embodiment, provisioning program **104** uses T_{US}, T_{CT}, T_{BC}, and T_{BE} as values to calculate T_{TS}. Provisioning program **104** calculates T_{TS} by adjusting the value for T_{US} by adding T_{CT} and T_{BC} and subtracting T_{BE}. For example, provisioning program **104** might identify the values it needs as T_{US} to be 9:00 am, T_{CT} to be 2 hours, and T_{BC} to be 3 hours and T_{BE} to be 4 hours. Provisioning program **104** would then calculate T_{TS} by adding the values for T_{CT} and T_{BC} (2 hours plus 3 hours), subtracting that value by T_{BE} (5 hours minus 4 hours) and adjusting T_{US} (9:00 am) by 1 hour ($T_{CT}+T_{BC}-T_{BE}$) to give T_{TS} value of 10:00 am. In alternative embodiments, provisioning program **104** could use other values to determine T_{TS}.

In step **404**, provisioning program **104** determines whether ($T_{TS}+T_{BE}$) complies with a user's schedule. The value of ($T_{TS}+T_{BE}$) represents the time at which the environment would be finished being built (i.e., finished allocating and configuring necessary resources, such that code written for, or otherwise affected by, the coding task can be tested), if building the environment began at T_{TS}. A user's schedule represents the available times that a user can begin testing one or more portions of code using the built environment. In an alternative embodiment, provisioning program **104** identifies the user schedule from historical data which indicates times a user has previously been available to begin testing. For example, if provisioning program **104** determined ($T_{TS}+T_{BE}$) to be 2:00 pm, provisioning program **104** would compare whether the user schedule provided by historical data indicates that the user will be available to work at 2:00 pm. In alternative embodiments, provisioning program **104** could receive indications from project management tracking tool **112** for user schedules. Alternatively, provisioning program **104** could access user schedules from another program, such as a shared calendar program.

If, in step **404**, provisioning program **104** determines that the value of ($T_{TS}+T_{BE}$) complies with a user's schedule, then, in step **406**, provisioning program **104** sets T_{TS} as the time to start building the environment (T_{SBE}). T_{SBE} represents the predicted time to start building the environment so that the environment is ready for use when the user is available to begin testing.

If, in step **404**, provisioning program **104** determines that ($T_{TS}+T_{BE}$) does not comply with a user's schedule, then, in step **408** provisioning program **104** determines a next available time to begin testing (T_{NA}), which is the earliest available time that the user can begin testing one or more portions of code using the built environment, and sets T_{SBE} as ($T_{NA}-T_{BE}$). In this embodiment, provisioning program **104** identifies T_{NA} using the same historical data and/or schedule that was checked in step **404** and sets that value as T_{TS}. For example, if a user consistently begins work at 9:00 am, provisioning program **104** can use that value as the earliest available time a user can begin testing one or more portions of code using the built environment. In alternative embodiments, provisioning program **104** prompts the user of project management tracking tool **112** to input earliest available time to start provisioning and sets that value as T_{NA}. Provisioning program **104** then subtracts the value for T_{BE} from the value for T_{NA} to and sets the resulting value as T_{SBE}. For example, if provisioning program **104** determined T_{NA} to be 2:00 pm and T_{BE} to be two hours, provisioning program adjusts T_{NA} by subtracting two hours to yield a T_{SBE} of 12:00 pm.

Accordingly, by performing the operational steps of FIG. **4**, provisioning program **104** calculates T_{SBE} for the coding task such that the environment is available to the user when the user and code are ready for testing; which, again, can reduce the "lag time" the user experiences between waiting for an environment to be built for testing programming code written for, and/or otherwise affected by the coding task. Provisioning program **104** can also calculate a T_{SBE} for the coding task based on user availability such that the environment is not prepared too far in advance so as to create "lag time" for other users who might need those resources.

FIG. **5** depicts a block diagram of components of computer system **500** which is representative of the computer systems of FIG. **1**, in accordance with an illustrative embodiment of the present invention. It should be appreciated that FIG. **1** provides only an illustration of one implementation and does not imply any limitations with regard to the environments in which different embodiments may be implemented. Many modifications to the depicted environment may be made. In general, the components illustrated in FIG. **5** are representative of any electronic device capable of executing machine-readable program instructions. Examples of computer systems, environments, and/or configurations that may be represented by the components illustrated in FIG. **5** include, but are not limited to, personal computer systems, server computer systems, thin clients, thick clients, laptop computer systems, table computer systems, cellular telephones (e.g., smart phones), multiprocessor systems, microprocessor-based systems, network PCs, minicomputer systems, mainframe computer systems, and distributed cloud computing environments that include any of the above systems or devices.

Computer system **500** includes communications fabric **502**, which provides communications between computer processor(s) **504**, memory **506**, persistent storage **508**, communications unit **512**, and input/output (I/O) interface(s) **514**. Communications fabric **502** can be implemented with any architecture designed for passing data and/or control information between processors (such as microprocessors, communications and network processors, etc.), system memory, peripheral devices, and any other hardware components within a system. For example, communications fabric **502** can be implemented with one or more buses.

Memory **506** and persistent storage **508** are computer-readable storage media. In this embodiment, memory **506** includes random access memory (RAM) **516** and cache memory **518**. In general, memory **506** can include any suitable volatile or non-volatile computer-readable storage media.

Persistent storage **508** may include, for example, a plurality of a magnetic hard disk drives. Alternatively, or in addition to a magnetic hard disk drive, persistent storage **508** can include a solid state hard drive, a semiconductor storage device, read-only memory (ROM), erasable programmable read-only memory (EPROM), flash memory, or any other computer-readable storage media that is capable of storing program instructions or digital information.

The media used by persistent storage **508** may also be removable. For example, a removable hard drive may be used for persistent storage **508**. Other examples include optical and magnetic disks, thumb drives, and smart cards that are inserted into a drive for transfer onto another computer-readable storage medium that is also part of persistent storage **508**.

Communications unit **512**, in these examples, provides for communications with other data processing systems or devices via a (e.g., network **114**). In this embodiment, communications unit **512** includes network adaptors or interfaces such as TCP/IP adapter cards, wireless Wi-Fi interface cards, or 3G or 4G wireless interface cards or other wired or wireless communication links. The network can comprise, for example, copper wires, optical fibers, wireless transmission, routers, firewalls, switches, gateway computers, and/or edge servers. Software and data used to practice embodiments of the present invention can be downloaded to server computer system **102** through communications unit **512** (e.g., via the Internet, a local area network, or other wide area network). From communications unit **512**, the software and data can be loaded onto persistent storage **508**.

I/O interface(s) **514** allows for input and output of data with other devices that may be connected to server computer system **102**. For example, I/O interface **514** may provide a connection to external devices **520** such as a keyboard, keypad, a touch screen, and/or some other suitable input device. External devices **520** can also include portable computer-readable storage media such as, for example, thumb drives, portable optical or magnetic disks, and memory cards. Software and data used to practice embodiments of the present invention, e.g., provisioning program **104**, can be stored on such portable computer-readable storage media and can be loaded onto persistent storage **508** via I/O interface(s) **514**. I/O interface(s) **514** also connect to a display **522**.

Display **522** provides a mechanism to display data to a user and may be, for example, a computer monitor.

The programs described herein are identified based upon the application for which they are implemented in a specific embodiment of the invention. However, it should be appreciated that any particular program nomenclature herein is used merely for convenience, and thus the invention should not be limited to use solely in any specific application identified and/or implied by such nomenclature.

The flowchart and block diagrams in the Figures illustrate the architecture, functionality, and operation of possible implementations of systems, methods and computer program products according to various embodiments of the present invention. In this regard, each block in the flowchart or block diagrams may represent a module, segment, or portion of code, which comprises one or more executable instructions for implementing the specified logical function(s). It should also be noted that, in some alternative implementations, the functions noted in the block may occur out of the order noted in the figures. For example, two blocks shown in succession may, in fact, be executed substantially concurrently, or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved. It will also be noted that each block of the block diagrams and/or flowchart illustration, and combinations of blocks in the block diagrams and/or flowchart illustration, can be implemented by special purpose hardware-based systems that perform the specified functions or acts, or combinations of special purpose hardware and computer instructions.

The present invention may be a system, a method, and/or a computer program product. The computer program product may include a computer readable storage medium (or media) having computer readable program instructions thereon for causing a processor to carry out aspects of the present invention.

The computer readable storage medium can be a tangible device that can retain and store instructions for use by an instruction execution device. The computer readable storage medium may be, for example, but is not limited to, an electronic storage device, a magnetic storage device, an optical storage device, an electromagnetic storage device, a semiconductor storage device, or any suitable combination of the foregoing. A non-exhaustive list of more specific examples of the computer readable storage medium includes the following: a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), a static random access memory (SRAM), a portable compact disc read-only memory (CD-ROM), a digital versatile disk (DVD), a memory stick, a floppy disk, a mechanically encoded device such as punch-cards or raised structures in a groove having instructions recorded thereon, and any suitable combination of the foregoing. A computer readable storage medium, as used herein, is not to be construed as being transitory signals per se, such as radio waves or other freely propagating electromagnetic waves, electromagnetic waves propagating through a waveguide or other transmission media (e.g., light pulses passing through a fiber-optic cable), or electrical signals transmitted through a wire.

Computer readable program instructions described herein can be downloaded to respective computing/processing devices from a computer readable storage medium or to an external computer or external storage device via a network, for example, the Internet, a local area network, a wide area network and/or a wireless network. The network may comprise copper transmission cables, optical transmission fibers, wireless transmission, routers, firewalls, switches, gateway computers and/or edge servers. A network adapter card or network interface in each computing/processing device receives computer readable program instructions from the network and forwards the computer readable program instructions for storage in a computer readable storage medium within the respective computing/processing device.

Computer readable program instructions for carrying out operations of the present invention may be assembler instructions, instruction-set-architecture (ISA) instructions, machine instructions, machine dependent instructions, microcode, firmware instructions, state-setting data, or either source code or object code written in any combination of one or more programming languages, including an object oriented programming language such as Smalltalk, C++ or the like, and conventional procedural programming languages, such as the "C" programming language or similar programming languages. The computer readable program instructions may execute entirely on the user's computer, partly on the user's computer, as a stand-alone software package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In the latter scenario, the remote computer may be connected to the user's computer through any type of network, including a local area network (LAN) or a wide area network (WAN), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider). In some embodiments, electronic circuitry including, for example, programmable logic circuitry, field-programmable gate arrays (FPGA), or programmable logic arrays (PLA) may execute the computer readable program instructions by utilizing state information of the computer readable program instructions to personalize the electronic circuitry, in order to perform aspects of the present invention.

Aspects of the present invention are described herein with reference to flowchart illustrations and/or block diagrams of methods, apparatus (systems), and computer program products according to embodiments of the invention. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer readable program instructions.

These computer readable program instructions may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks. These computer readable program instructions may also be stored in a computer readable storage medium that can direct a computer, a programmable data processing apparatus, and/or other devices to function in a particular manner, such that the computer readable storage medium having instructions stored therein comprises an article of manufacture including instructions which implement aspects of the function/act specified in the flowchart and/or block diagram block or blocks.

The computer readable program instructions may also be loaded onto a computer, other programmable data processing apparatus, or other device to cause a series of operational steps to be performed on the computer, other programmable apparatus or other device to produce a computer implemented process, such that the instructions which execute on the computer, other programmable apparatus, or other device implement the functions/acts specified in the flowchart and/or block diagram block or blocks.

The flowchart and block diagrams in the figures illustrate the architecture, functionality, and operation of possible implementations of systems, methods, and computer program products according to various embodiments of the present invention. In this regard, each block in the flowchart or block diagrams may represent a module, segment, or portion of instructions, which comprises one or more executable instructions for implementing the specified logical function(s). In some alternative implementations, the functions noted in the block may occur out of the order noted in the figures. For example, two blocks shown in succession may, in fact, be executed substantially concurrently, or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved. It will also be noted that each block of the block diagrams and/or flowchart illustration, and combinations of blocks in the block diagrams and/or flowchart illustration, can be implemented by special purpose hardware-based systems that perform the specified functions or acts or carry out combinations of special purpose hardware and computer instructions.

The descriptions of the various embodiments of the present invention have been presented for purposes of illustration, but are not intended to be exhaustive or limited to the embodiments disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art without departing from the scope and spirit of the invention. The terminology used herein was chosen to best explain the principles of the embodiment, the practical application or technical improvement over technologies found in the marketplace, or to enable others of ordinary skill in the art to understand the embodiments disclosed herein.

What is claimed is:

1. A computer program product for building a test environment, the computer program product comprising:

one or more computer-readable storage media and program instructions stored on the one or more computer-readable storage media, the program instructions comprising:

program instructions to identify a coding task to be performed by a user, wherein the coding task involves one or more portions of code for a software program;

program instructions to identify resources with which to build a test environment for the coding task based, at least in part, on one or more areas of the software program associated with the one or more portions of code, wherein the test environment to be built includes accommodations for at least one of the following: testing one or more portions of code, replicating pre-production environments, or replicating an actual production environment; and

program instructions to predict a time at which to start building the test environment such that the test environment is built and made available to the user by the time the user is prepared to test the one or more portions of code in the test environment.

2. The computer program product of claim **1**, further comprising:

program instructions to determine whether an existing test environment will be available for testing the one or more portions of code when the user is prepared to test the one or more portions of code; and

program instructions to, responsive to determining an existing test environment will be available for testing the one or more portions of code when the user is prepared to test the one or more portions of code, reserving the existing test environment for the coding task.

3. The computer program product of claim **1**, further comprising:

program instructions to determine whether resources will be available for building the test environment at the predicted time at which to start building the test environment, such that the test environment is built and made available to the user by the time the user is prepared to test the one or more portions of code in the test environment; and program instructions to, responsive to determining resources will not be available for building the environment at the predicted time at which to start building the test environment, such that the test environment is built and made available to the user by the time the user is prepared to test the one or more portions of code in the test environment, alerting the user.

4. The computer program product of claim 1, wherein the program instructions to identify a coding task to be performed by a user comprise:

program instructions to access a task repository containing task information associated with the coding task; and

program instructions to determine that the user has begun work on the coding task, wherein the task information comprises:

a title of the coding task, a brief description of the coding task, information that describes one or more areas of the software program affected by the coding task, an estimated time to complete the coding task, and a status indicating a progress state of the coding task.

5. The computer program product of claim 1, wherein the program instructions to identify resources with which to build a test environment for the coding task comprises:

program instructions to access a pool of resources;

program instructions to identify resources associated with terms found in the task information; and

program instructions to identify resources that have historically been used to build test environments for similar coding tasks.

6. The computer program product of claim 1, wherein the program instructions to calculate a time at which to start building the test environment such that the test environment is built when the user is prepared to test the one or more portions of code in the test environment comprise:

program instructions to calculate a time at which to start building the test environment based, at least in part, on an identified length of time to perform any necessary builds of code, an identified length of time to complete the coding task, an identified start time at which the user began work on the coding task, and an identified length of time needed to build the environment, wherein the identified length of time needed to build the test environment comprises a total length of time needed to allocate the identified resources from a resource pool and configure those resources into a test environment for the coding task.

7. A computer system for building a test environment, the computer system comprising:

one or more computer processors;

one or more computer-readable storage media;

program instructions stored on the computer-readable storage media for execution by at least one of the one or more processors, the program instructions comprising:

program instructions to identify a coding task to be performed by a user, wherein the coding task involves one or more portions of code for a software program;

program instructions to identify resources with which to build a test environment for the coding task based, at least in part, on one or more areas of the software program associated with the one or more portions of code, wherein the test environment to be built includes accommodations for at least one of the following: testing one or more portions of code, replicating pre-production environments, or replicating an actual production environment; and

program instructions to predict a time at which to start building the test environment such that the test environment is built and made available to the user by the time the user is prepared to test the one or more portions of code in the test environment.

8. The computer system of claim 7, further comprising:

program instructions to determine whether an existing test environment will be available for testing the one or more portions of code when the user is prepared to test the one or more portions of code; and

program instructions to, responsive to determining an existing test environment will be available for testing the one or more portions of code when the user is prepared to test the one or more portions of code, reserving the existing test environment for the coding task.

9. The computer system of claim 7, further comprising:

program instructions to determine whether resources will be available for building the test environment at the predicted time at which to start building the test environment such that the test environment is built and made available to the user by the time the user is prepared to test the one or more portions of code in the test environment; and

program instructions to, responsive to determining resources will not be available for building the test environment at the predicted time at which to start building the test environment such that the test environment is built and made available to the user by the time the user is prepared to test the one or more portions of code in the test environment, alerting the user.

10. The computer system of claim 7, wherein the program instructions to identify a coding task to be performed by a user comprises:

program instructions to access a task repository containing task information associated with the coding task; and

program instructions to determine that the user has begun work on the coding task, wherein the task information comprises:

a title of the coding task, a brief description of the coding task, information that describes one or more areas of the software program affected by the coding task, an estimated time to complete the coding task, and a status indicating a progress state of the coding task.

11. The computer system of claim 7, wherein the program instructions to identify resources with which to build a test environment for the coding task comprises:

program instructions to access a pool of resources;

program instructions to identify resources associated with terms found in the task information; and

program instructions to identify resources that have historically been used to build test environments for similar coding tasks.

12. The computer system of claim 7, wherein the program instructions to calculate a time at which to start building the test environment such that the test environment is built when the user is prepared to test the one or more portions of code in the test environment comprise:

program instructions to calculate a time at which to start building the test environment based, at least in part, on an identified length of time to perform any necessary builds of code, an identified length of time to complete the coding task, an identified start time at which the user began work on the coding task, and an identified length of time needed to build the test environment, wherein the identified length of time needed to build the test environment comprises a total length of time needed to allocate the identified resources from a resource pool and configure those resources into a test environment for the coding task.

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